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REPORT

OF THE

MASSACHUSETTS STATE FORESTER

TO THE

RESERVOIR COMMISSION

OF THE

CITY OF FALL RIVER,

WITH RECOMMENDATIONS FOR THE PROTECTION AND MAINTENANCE OF THE WATERSHED OF NORTH WATUPPA POND.

F. W. RANE, STATE FORESTER.
H. O. COOK, ASSISTANT IN CHARGE.

DECEMBER, 1908.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1909.

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PREFACE.

At the invitation of the Reservoir Commission of the City of Fall River, — a Board created for the purpose of protecting the purity of the city's water supply, — the State Forester's department has made an examination of the watershed of the North Watuppa Pond, located in the city of Fall River and the town of Westport, and herewith presents the results of said examination, with such recommendations as to it seem wise.

ACKNOWLEDGMENTS.

To Mr. H. O. Cook, M.F., my assistant in charge, is due the credit of carrying out and completing this work; and to His Honor Mayor John F. Coughlin, City Water Commissioner Wm. Sullivan and City Engineer Philip D. Borden of the Reservoir Commission we are greatly indebted for their interest and many courtesies.

F. W. RANE,
State Forester.

STATE HOUSE, BOSTON, MASS.

By Transfer

JAN 13 1912

Part I.

Influence of Forests on Water Supplies.

Although this is a subject of great importance to this country, and one much discussed of late, it has never been carefully studied. Even European foresters, who have investigated this subject for many years, have not as yet established their final conclusions covering the whole field. That a relation does exist is indisputable, for forest destruction always produces a change in the character of the stream flow.

Influence of Forests on Rainfall.

Rainfall is caused by the cooling of moisture-laden air to below the dew point. Forests shade the ground, making it cooler and consequently keeping the air above it at a lower temperature than that of the surrounding air. It is reasonable to suppose that rain might fall over a forested area when it would not if that area were cleared. On the western prairies this is a popular conviction, but observations made in Europe have yielded conflicting results, and no definite conclusion can be drawn from them.

Influence upon the Disposal of Rainfall.

It is after the rain has reached the earth that the forest exerts its most potent influence. Rainfall escapes in four ways from the ground upon which it falls: by evaporation, transpiration, surface run-off and seepage run-off.

Evaporation.

The rapidity with which moisture evaporates depends on its exposure to the sun and wind. A thick forest cover shades the ground from the direct rays of the sun, thus preventing too rapid evaporation. Experiment has shown that from the surface of a small pond, situated in the open, three to four times as much evaporation took place as from a similar sheet of water in the forest. Experiments made on the surface soil in California gave practically the same results. From 1,000 square centimeters of bare ground 5,730 grams of water were

evaporated in the months of July and August; while from ground under a heavy mulch of leaves on the forest floor it was but 1,150 grams. In the thick spruce woods of Maine one will often find snow on the ground in June, whereas in the open it disappeared before the first of May. Evaporation is profoundly affected by wind. Observations of the United States Weather Bureau indicate that with a wind velocity of 5 miles an hour, other conditions being equal, the rate of evaporation is 2.2 times that of a calm; at 10 miles an hour, 3.8; at 20 miles, 5.7; and so on. It will be readily seen that, by the check in the velocity of the wind that a forest cover causes, the amount of water lost in this way is greatly reduced. Not only is the force of the wind broken within the woodland, but it is retarded for a considerable distance to the leeward. In general, the retardation is felt over 20 feet of horizontal distance for every foot in the height of the trees. Thus a stand of trees 50 feet in height all around North Watuppa Pond would materially reduce the evaporation caused by the wind over a water surface of 1.4 square mile, or about one-half the total area of the pond.

Transpiration.

Vegetation in the process of growth uses up a large amount of water, which is gathered from the soil by the roots and is then transpired to the air through the leaves. Only a small portion of it remains in the structure of the plant. From a lengthy series of experiments, Risler came to the conclusion that a forest takes up less than one-half as much water as an ordinary agricultural crop. We infer from this that a soil covered with grass or other herbaceous growth loses more moisture from this cause than one covered by a forest.

Different species of trees take up varying amounts of water. For deciduous species the average amount during one season is 470 pounds of water for every pound of leaf matter; but in the case of coniferous trees it is but 43 pounds, or one-tenth as much. In one or two other respects a broad-leaf wood has slight advantages over the evergreen one as a conserver of moisture; but this matter of transpiration points to the latter as the most efficient protector of water supplies.

Evaporation and transpiration represent actual losses of water. Just how great this loss is, will appear from the following table, taken from the excellent report of the Reservoir Commission for 1902. We are indebted to Mr. Safford's work for a great deal of careful information used directly and indirectly in this report. This table shows the precipitation on the watershed of North Watuppa Pond, compared with the amount of water which found its way into the pond, for the different months of the years 1899 to 1902. On the average, nearly

50 per cent. of the total rainfall was lost. Although there were undoubtedly other factors of waste, the larger part of the loss must have come from evaporation and transpiration. A minus sign indicates that the evaporation from the water surface was greater than the total amount coming into the pond; consequently, the amount collected was a minus quantity.

TABLE SHOWING THE AVERAGE NUMBER OF INCHES OF PRECIPITATION WHICH HAVE FALLEN ON THE NORTH POND WATERSHED, COMPARED WITH THE ACTUAL YIELD OF THE POND, REDUCED TO INCHES, COLLECTED ON THIS WATERSHED.

[Watershed of North Watuppa Pond, 11.444 square miles; area of North Watuppa Pond at "full pond," 24.7 per cent. of this, or 2.821 square miles.]

MONTHS.	1899.			1900.			1901.		
	Average Precipitation on North Pond Watershed (Inches).	Number of Inches collected.	Per Cent. of Precipitation collected.	Average Precipitation on North Pond Watershed (Inches).	Number of Inches collected.	Per Cent. of Precipitation collected.	Average Precipitation on North Pond Watershed (Inches).	Number of Inches collected.	Per Cent. of Precipitation collected.
January,	5.624	5.011	89.10	4.520	2.201	48.69	2.220	1.301	58.60
February,	3.840	4.375	113.93	5.125	4.067	79.36	0.948	0.483	50.95
March,	6.187	7.253	117.23	4.017	4.014	99.93	6.835	4.823	70.56
April,	2.174	2.654	122.08	2.100	1.638	78.00	8.390	7.129	84.97
May,	1.810	1.009	55.75	5.330	2.942	55.20	8.050	5.404	67.13
June,	3.858	0.095	2.46	1.682	—0.221	—13.14	1.685	1.159	68.78
July,	2.785	—0.285	—10.23	2.917	—0.519	—17.79	3.185	—0.054	—1.70
August,	1.641	—0.525	—31.99	2.020	—0.489	—24.21	2.462	0.033	1.34
September,	7.056	1.112	15.76	3.537	0.109	3.08	2.510	—0.281	—11.20
October,	1.937	0.681	35.16	5.002	0.941	18.81	3.173	0.368	11.60
November,	2.215	0.565	25.51	3.925	1.319	33.61	2.177	0.420	19.29
December,	1.260	0.735	58.33	2.460	1.590	64.63	8.640	4.384	50.74
Total,	40.387	22.680	–	42.635	17.592	–	50.275	25.169	–
Average,	–	–	56.16	–	–	41.26	–	–	50.06

Distribution of the Run-off.

There are two kinds of run-off, surface and seepage. The first is on the whole harmful, while the latter is beneficial. On cleared land the soil becomes baked and hardened by the sun, so that when the rain falls on it the water runs over the surface to the nearest stream. If the rain is heavy or the slope steep, the soil is washed and the brooks become filled with sediment and impurities. The forest, on the other hand, is provided with a floor of vegetable material, decayed leaves and branches, called humus, anywhere from 2 inches to 2 feet in the thickness. This humus has great absorbing powers, and acts as a huge sponge, converting the surface drainage into a seepage run-off. Ebermayer estimates that the water-storing capacity of humus is considerably more than its own weight; while Henry, from laboratory experiments, "Revue des Eaux et Forêts," makes it four times its own weight. The interlocked roots of the trees prevent any washing of the soil.

By converting a surface run-off into a seepage run-off, water which comes in the season of excess rainfall is kept in the ground to feed the springs during the time when rainfall is deficient. It is not generally considered that this region has a distinct rainy season, but there is a period in the year when more than the average amount of rain falls. The following table shows the average monthly rainfall for the region to be 3.96 inches; for the four months December to March inclusive it is 4.24 inches, and during the months from June to September it averages 3.50 inches a month, — a loss of about 17 per cent. from the winter average.

Average Monthly Rainfall (Inches).

Months.	Fall River Water Works for 1899, "Old Gauge."	Fall River Water Works Average for Twenty-nine Years, "Old Gauge."	Providence, Average for Seventy Years.	New Bedford, Average for Seventy Years.
January,	5.84	4.91	4.08	4.08
February,	4.11	4.41	3.80	3.71
March,	7.44	5.19	4.17	4.29
April,	2.92	4.22	3.72	3.95
May,	1.82	3.91	3.80	4.02
June,	4.46	3.02	3.17	3.05
July,	3.37	3.64	3.32	3.31
August,	1.85	4.29	4.13	4.02
September,	7.90	3.41	3.26	3.39
October,	2.39	4.68	3.73	3.98
November,	2.44	5.36	4.16	4.29
December,	1.45	4.02	3.91	4.24
Totals,	45.99	51.06	45.25	46.33

The excess amount of rainfall comes at a time when the least amount of water is being used by the citizens of Fall River. The following table gives the monthly and average daily consumption, as indicated by the gauges at the water works, for the year 1901. The increase in the summer consumption is at times nearly 50 per cent. This and other causes, such as increased evaporation, makes a loss in the water stored in the pond during the warm months.

CONSUMPTION FOR 1901.

MONTHS.	Total Consumption of Water from Water Works Report (U. S. Gals.).	Gain in Water stored in North Pond during Month (U. S. Gals.).	Loss in Water stored in North Pond during Month (U. S. Gals.).	Consumption of Water, Average Daily for Month, from Water Works Report (U. S. Gals.).
January,	97,758,000	24,136,000	–	3,121,000
February,	90,661,000	–	90,967,000	3,238,000
March,	99,353,000	701,128,000	–	3,205,000
April,	95,435,000	827,254,000	–	3,181,000
May,	105,380,000	87,696,000	–	3,399,000
June,	112,160,000	–	137,196,000	3,739,000
July,	126,741,000	–	408,037,000	4,088,000
August,	121,262,000	–	390,986,000	3,912,000
September,	122,440,000	–	325,630,000	4,081,000
October,	122,095,000	–	219,712,000	3,939,000
November,	112,680,000	–	99,263,000	3,756,000
December,	114,875,000	633,152,000	–	3,706,000
Totals,	1,320,840,000	2,273,366,000	1,671,791,000	–
Average,	–	–	–	3,619,000

If a dam could be constructed at the "Narrows" which would hold all the excess of water that would accumulate in the winter months, the regulation of the run-off by the forest cover would not hold such an important place in this report. But because of riparian rights held by the Reservoir Company, which controls the water power for the mills on the Quequechan River, the city is obliged to let the water flow freely from North Pond into South Pond until the level of the former is 40 inches below full pond, after which they can shut the flowage down to 5,000,000 gallons a day. In other words, it is impossible for the city to lay up a store of water in North Pond against the time of need; they can only husband it when the time of need arrives. The rainfall must be stored in the earth, and to bring this about, the watershed of the pond must have a forest cover.

Purifying Influence of Forests on Water.

We could not find that any investigations on this subject have ever been made. It seems reasonable to suppose that forests do exert some influence in this direction, because water is purified by percolating through the earth, so that a seepage run-off should yield a better supply of water than a run-off from the surface. In a table taken from Mr. Safford's report, which gives the results of analyses made by the State Board of Health on samples of water from the pond and from its various feeders, we find that the water in the pond is considerably the purer. As only about 50 per cent. of the water supply of the pond comes through the brooks or by direct precipitation, the remainder must be fed to it by springs in the bottom of the pond. We conclude, therefore, that the water from these springs (deep seepage flow) is purer than that of the brooks, which carry a deal of surface run-off, and the standard of purity of the whole pond is raised thereby.

WATER ANALYSES BY STATE BOARD OF HEALTH, MAY 23, 1899. — BROOKS TRIBUTARY TO NORTH WATUPPA POND.

[Parts per 100,000.]

NUMBER.	DATE OF —		APPEARANCE.			ODOR.		RESIDUE ON EVAPORATION.			AMMONIA.				CHLORINE.	NITROGEN AS —		OXYGEN CONSUMED.	HARDNESS.	NAME OF BROOK.
												ALBUMINOID.								
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Fixed.	Free.	Total.	In Solution.	In Suspension.		Nitrates.	Nitrites.			
27208	May 23.	May 24.	V. slight.	Slight.	3.00	Faint veg.	Faint veg.	6.70	4.75	1.95	.0052	.0476	.0436	.0040	.49	.0010	.0000	3.12	0.8	Blossom.
27209	May 23.	May 24.	Slight.	Cons.	0.05	Faint veg.	Faint veg.	4.75	1.00	3.75	.0040	.0179	.0132	.0047	.75	.0180	.0001	.13	1.0	Cress.
27210	May 23.	May 24.	V. slight.	V. slight.	1.00	Faint veg.	Dist. veg.	5.50	2.20	3.30	.0020	.0278	.0262	.0016	.49	.0250	0000	1.10	1.0	Highland.
27211	May 23.	May 24.	V. slight.	V. slight.	1.90	Faint veg.	Dist. veg.	5.20	3.05	2.15	.0036	.0208	.0296	.0012	.46	.0010	.0000	2.10	0.3	King Philip.
27212	May 23.	May 24.	V. slight.	Cons.	0.70	Faint veg.	Dist. veg.	6.50	2.25	4.25	.0066	.0520	.0468	.0052	.81	.0050	.0001	1.03	1.3	Nat, north branch.
27213	May 23.	May 24.	Slight.	Cons.	1.65	Faint veg.	Dist. veg.	5.75	3.50	2.25	.0086	.0622	.0570	.0052	.45	.0000	.0000	2.02	0.8	Nat, south branch.
27214	May 23.	May 24.	V. slight.	Slight.	1.55	Faint veg.	Dist. veg.	4.35	2.60	1.75	.0044	.0300	.0284	.0016	.45	.0000	.0000	1.70	0.3	Queen Gutter.
27215	May 23.	May 24.	Decided.	Slight.	1.30	Faint veg. to mould.	Dist. veg.	5.50	2.50	3.00	.0046	.0384	.0316	.0068	.59	.0240	.0002	1.22	0.5	Ralph.
27216	May 23.	May 24.	V. slight.	Cons. green.	1.40	Faint veg.	Faint veg.	4.20	2.40	1.80	.0016	.0196	.0168	.0028	.48	.0040	.0000	1.38	0.3	Run.
27217	May 23.	May 24.	Slight.	Slight.	1.05	Faint veg.	Dist. veg.	5.45	2.80	2.65	.0100	.0472	.0460	.0012	.46	.0050	.0002	1.30	0.8	Terry.
27098	May 15.	May 15.	V. slight.	V. slight.	0.29	V. faint veg.	Faint veg.	3.05	1.20	1.85	.0004	.0180	.0160	.0020	.43	.0060	.0001	.46	0.3	North Watuppa Lake.
27099	May 15.	May 15.	V. slight.	V. slight.	0.30	Faint veg.	Dist. veg. and faint grassy.	3.80	1.70	2.10	.0022	.0352	.0330	.0022	.58	.0090	.0001	.51	0.5	South Watuppa Lake.

Forestry from a Commercial Standpoint.

Although it is in its relation to water supply that the woodland around North Watuppa Pond interests us chiefly, there is a financial side to forestry which is worth noting. In Europe, trees are raised and harvested like an agricultural crop; and in time we in this country must come to the same methods. There is an important difference between agriculture and forestry, in that trees take many years to grow, while the agricultural crop is raised and harvested in a single season. This time element prevents many people from taking much interest in tree culture, for they cannot see the advantage in investing in a property the returns from which they may not live to enjoy. In the case of a municipality or a State, however, this objection does not hold, because their span of life is, theoretically at least, without limit. They need have no fear that they will not live to realize on their investment.

It is in Germany that forestry was first practised, and where it has reached its highest development. What the results have been is told in Circular No. 140 of the United States Forest Service. The chapter of that document which relates to Germany is quoted in full, as follows: —

Germany.

The German Empire has nearly 35,000,000 acres of forest, of which 31.9 per cent. belongs to the State, 1.8 per cent. to the Crown, 16.1 per cent. to communities, 46.5 per cent. to private persons, 1.6 per cent. to corporations, and the remainder to institutions and associations. There is a little over three-fifths of an acre of forest for each citizen, and, though 53 cubic feet of wood to the acre are produced in a year, wood imports have increasingly exceeded wood exports for over forty years, and 300,000,000 cubic feet, valued at $80,000,000, or over one-sixth of the home consumption, are now imported each year. Germany's drains on foreign countries are in the following order: Austria-Hungary, 19,750,000 tons; Russia and Finland, 18,000,000 tons; Sweden, 508,000 tons; the United States, 360,000 tons; Norway, 49,000 tons.[1]

German forestry is remarkable in three ways. It has always led in scientific thoroughness, and now it is working out results with an exactness almost equal to that of the laboratory; it has applied this scientific knowledge with the greatest technical success; and it has solved the problem of securing through a long series of years an increasing forest output and increasing profits at the same time.

Like other advanced European countries, Germany felt the pinch of wood shortage a hundred and fifty years ago, and, though this shortage

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[1] According to the kind of wood, a ton is equivalent to from about 500 to about 1,000 board feet.

was relieved by the coming of the railroads, which opened up new forests, and by the use of coal, which substituted a new fuel for wood, the warning was heeded, and systematic State forestry was begun. After all, the scare was not a false one, for even to-day Germany is not independent as regards wood, since she has to import one-sixth of all she uses.

In addition to the wood-supply question, Germany was forced to undertake forestry by the need of protecting agriculture and stream flow. The troubles which France was having with her mountain torrents opened the eyes of the Germans to the dangers from floods in their own land. As a result, the maintenance of protective forests was provided for by Bavaria in 1852, by Prussia in 1875, and by Württemberg in 1879.

Each State of the German federation administers its own forests. All of the States practise forestry with success. The results obtained by Prussia and Saxony are particularly interesting, for they show how forests may be kept constantly improving under a system of management which yields a handsome profit.[1]

The Prussian forests, covering nearly 7,000,000 acres, are made up much as if we should combine the pineries of the Southern States with the forests of some of our Middle Atlantic and Central States. When forestry was begun, a great part of them had been injured by mismanagement, much as our forests have been, and the Prussian foresters had to solve the problem of improving the run-down forests out of the returns from those which were still in good condition. They solved it with striking success. Immense improvement has already taken place and is steadily going on.

The method of management adopted calls for a sustained yield, — that is, no more wood is cut than the forest produces. Under this management the growth of the forest, and consequently the amount cut, has risen sharply. In 1830 the yield was 20 cubic feet per acre; in 1865, 24 cubic feet; in 1890, 52 cubic feet; and in 1904, 65 cubic feet. In other words, Prussian forest management has multiplied the rate of production threefold in seventy-five years. And the quality of the product has improved with the quantity. Between 1830 and 1904 the percentage of saw timber rose from 19 per cent. to 54 per cent.

It is a striking fact in this connection that in the United States at the present time we are using about three times as much timber as our forests grow. If we were everywhere practising forestry with a resulting improvement equal to that made in Prussia, our forests would be growing as much as we use.

The financial returns in Prussia make an even better showing. Net returns per acre in 1850 were 28 cents. In 1865 they were 72 cents; in 1900, $1.58; and in 1904, $2.50. They are now nearly ten times what they were sixty years ago, and they are increasing more rapidly than ever.

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[1] See "Financial Results of Forest Management," by Dr. B. E. Fernow in "Forestry and Irrigation" for February, 1907.

These results have been obtained in Prussia along with almost ideal technical success. When what is wanted is a sustained yield from the forest year by year in the long run, it is clearly necessary to have always a certain number of trees ready to be cut; there must be a proper proportion of trees of all ages. This percentage has been secured and maintained with almost mathematical accuracy.

In Saxony, which has about 430,000 acres of State forests, the increase of cut under forest management, which always means also a corresponding increase in wood produced, has been nearly as marked as in Prussia. The yield rose 55 per cent. between 1820 and 1904, and is now 93 cubic feet per acre, — greater than that of the Prussian forests. Since the chief wood is spruce, which yields more saw timber than the average of trees making up the Prussian forests, the increase in the percentage of saw timber in Saxony naturally exceeds the increase in Prussia. It increased from 26 per cent. in 1830 to 66 per cent. in 1904. The net yearly revenue is $5.30 per acre. The yearly expense is $3 per acre.

These figures are in striking contrast with the corresponding ones for the United States. We spent on our national forests last year $9\frac{3}{10}$ mills per acre, and our net revenue from them was less than $\frac{7}{8}$ mill per acre.

The rise in prices, felt everywhere, accounts only in part for the increased financial returns from forestry in these two States; for, while the prices have not quite trebled, the revenue has been multiplied tenfold.

Other German States, smaller, and with better kinds of timber and better market facilities, secure even higher returns. The forests of Württemberg yield a net annual revenue of nearly $6 per acre, and those of several smaller administrations do even better.

A number of the private forests of Germany are managed with great success. As a result of a canvass of 15,600,000 acres of State, municipal and private forests, it was found that the average net revenue per acre, from good, bad and indifferent land, was $2.40 a year.

What, then, has forestry done in Germany? Starting with forests which were in as bad shape as many of our own which have been recklessly cut over, it raised the average yield of wood per acre from 20 cubic feet in 1830 to 65 cubic feet in 1904. During the same period of time it trebled the proportion of saw timber got from the average cut; which means, in other words, that through the practice of forestry the timberlands of Germany are of three times better quality to-day than when no system was used. And in fifty-four years it increased the money returns from an average acre of forest sevenfold.

Yet to-day the forests are in better condition than ever before, and under the present system of management it is possible for the German foresters to say with absolute certainty that the high yield and large returns which the forests now give will be continued indefinitely into the future.

Part II.

Topography.

The basin or watershed of North Watuppa Pond is small in comparison to the size of the pond. On the west side it consists of a strip of land averaging one-half mile in width, and with a rather steep slope down to the shore of the pond. In the center, however, there is a depression formed by the valleys of Terry and Highland brooks, which causes the limits of the watershed to extend back to a distance of a mile or more. On this inhabited side of the pond the soil is thin and underlaid with numerous ledges. There is but little swamp land, and what there is is found only along the shore of the pond and on the banks of the brooks.

On the eastern shore the watershed broadens out, and extends up a gentle slope to the summit and ridge of Copecut Hill. It averages one and one-half miles in width except in the southern part, where the watershed of Bread and Cheese Brook encroaches on that of the pond. The ground is so level here that the limits of the two basins are not readily distinguishable. From Blossom's Cove a swampy depression extends far back into the flanks of Copecut Hill, and includes most of the watersheds of King Philip and Blossom brooks. The soil on this side of the pond is generally a deep and stony sandy loam, well adapted to tree growth.

At the northerly end of the pond a basin with rather steep sides extends back for about a mile, and then ends abruptly. This basin is intersected by several small brooks, which are bordered by much swampy land.

The Map.

Before making definite recommendations for the care and reforestation of the large area of land which the city of Fall River owns around North Watuppa Pond, it was necessary to make the accompanying map. This land had all been surveyed to determine the limits of the watershed, the roads located and the lot lines run; but there was nothing to indicate the character of the land, — what is woodland and what is not, or what kind of woodland it is. It is evi-

SMALL HARDWOODS.

(Colored Yellow on Map.)

dent that if the boundaries of the fifteen types of land into which the area was divided were run out by the ordinary methods of survey, the work would take a long time and considerable money. Foresters have a method of map making which is rough and ready, but quick and cheap. Briefly, it consisted in running a series of lines with a hand compass and chain from the shore of the pond to the top of the watershed. The average distance between the lines was from 70 to 80 rods. On the eastern side topography was put in, but on the opposite side the city engineer is doing the same work by accurate methods of survey, so that we did not attempt to duplicate this work. The basis of this topographical work was obtained by levelling all the roads, and taking readings from an aneroid barometer while running the lines. Ordinarily, forest land does not vary a great deal within narrow limits; but the territory around the pond has been cut up into many small farms and woodlots, so that there is an intricate mingling of different types which offered considerable difficulty to a method of survey intended for large areas of forest in the wilderness. The map serves its purpose, however, and that is, to give the approximate area of the different types, so that some estimate of the amount of work to be done and the cost thereof can be made.

Types of Land.

The entire watershed of North Watuppa Pond covers 5,775 acres; but as plans are now under way to divert the waters of Cress and Highland brooks into the Quequechan River, on account of the pollution of their waters, their watersheds were omitted from the map, so that the total area surveyed is 4,784 acres. Of this area the city owns or controls 2,940, leaving 1,844 still to be acquired by it.

The whole watershed can be divided into two main types, — land with and land without tree growth. A large part of the former is around the northern half of the pond. There are 3,232 acres of the forested land to 1,552 of the non-forested. Of the city-owned land, 2,507 acres are forested and 433 acres cleared; while on the private land conditions are reversed, only 705 acres being forested and 1,119 acres cleared. It is unfortunate that so much of the open land that should be planted to tree growth is not in the hands of the city.

For purposes of treatment and description, the area has been divided into fifteen different types, ten of which lie in the forested portion of the watershed, and the rest includes the cleared portion. Twelve of the types are common to both the city and non-city land.

Even with this rather minute division, there is a good deal of variation in a single type. Often it was not easy to decide in what class to

put a certain lot. A piece of neglected grass land may appear like a pasture, or a cut-over maple swamp resemble a bush swamp. The differences are not important, however.

Young Sprout Land.

This type is found where a hardwood or a mixed hardwood and pine growth has been cut off during the past eight or ten years. The land is covered with a reproduction growth of oaks and chestnut sprouts, which vary in height from 2 feet in the youngest to 15 in the oldest. Some stands of thick young birch growth have been included in this type, although they are not of sprout origin. On most of this land no immediate treatment is necessary, but on lots 106–113 a fire ran through the young sprout growth and killed it over an area of about 150 acres. In order to restore this area to forest land, it will have to be planted. On lots 149, 150, 153, 153B, 157 and 160, which have just been cut off, the sprout growth is rather scattered on account of the large number of pines contained in the growth. Some planting in the open spaces might well be done here.

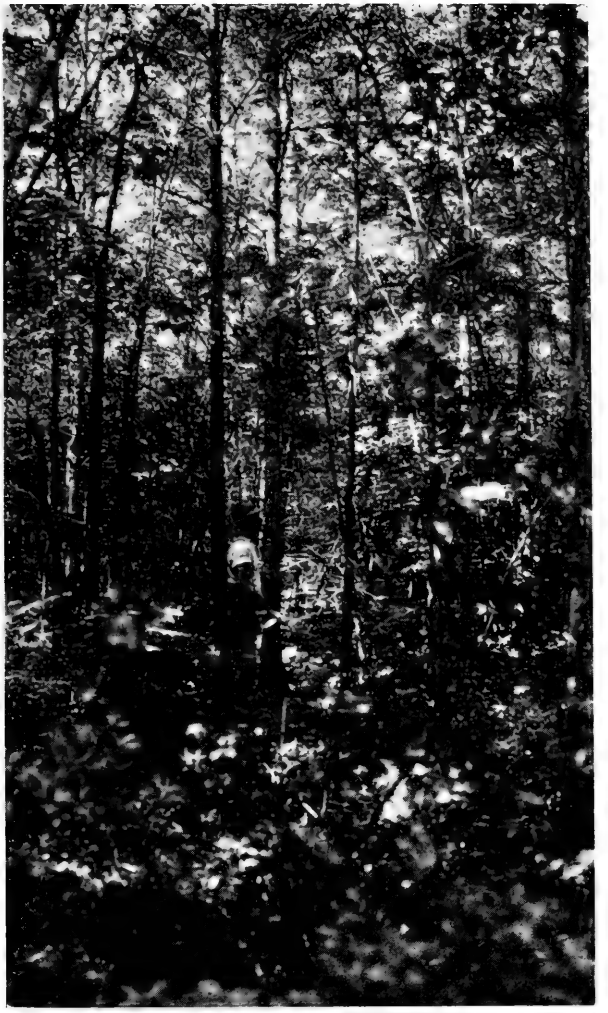
This type covers the largest area of all, and is in part the result of the policy of the city in buying woodland under the condition that the former owner should have the privilege of cutting the wood before a certain date. Unless this was done in many cases, the land could not be bought at any price; but it is a poor policy, from the view point of watershed regulation.

Cultivated Land.

Cultivated land means not only land under cultivation, but grass land and land occupied by buildings. Out of a total acreage of 1,117, the city owns but 190, and this area should be planted to tree growth. A good wood crop will be found to pay a better rental than is now obtained from this farm land as it is let out to be cultivated.

Maple Swamp.

This is the name given to the wooded swamp land which follows around the shore of the pond and along the courses of the brooks. Red or soft maple is the prevailing tree, but birch and alder are often mixed with it. The trees are usually small and of no commercial value; but the maple swamp area in Blossom Swamp contains some good-sized stands, which would be classed with the medium hardwoods. Some light thinning might be done in these stands, but in the rest of the growth no treatment is necessary.



MEDIUM HARDWOOD GROWTH.

(Colored Light Orange on Map.)

Maple Swamp, with Pine and Hemlocks.

This is a variation of the above type which is found in the Blossom Swamp region, and on the shore of the pond near Blossom's Cove. The trees are of good size, especially the pine and hemlock. It is estimated that the stand would run 25 cords of hardwoods, 10 cords of soft wood and 2 cords of thinning to the acre. As before, a light thinning is recommended, which would favor the pine and the hemlock at the expense of the other species.

Small Hardwoods.

This is a stage of the sprout growth next above that of the young sprout land. It consists of sprouts of oak (white, red and black) and chestnut, mixed with occasional specimens of other species, such as hickory, ash, maple, sassafras, and in some places pines. Stands of gray birch are included in this type also. The trees are from 15 to 30 feet in height and from 1 to 5 inches in diameter. It is estimated that this growth will yield 14 cords of small firewood to the acre, worth on the stump about $1. The thinnings will be of no commercial value. This type can be given a rather heavier thinning than the others, as it is young and vigorous, and will soon fill up all blanks left in the cover. The chestnuts should be favored at the expense of the oaks, and the occasional pines favored by having the young hardwoods cut from around them.

Medium Hardwoods.

Sprout hardwood growth which has attained a height of from 25 to 45 feet and diameters from 3 to 9 inches is put in this class. On much of the city land bearing this type the former owners still hold options to cut. In a few cases these options have been repurchased, and it is recommended that the practice be continued, lest all the wooded portion of the watershed be turned into cut-over land. This stand is estimated to run 20 cords to the acre, with thinnings which will give 1½ cords of small-sized firewood. The stumpage value is $1 per cord.

Large Hardwoods.

This is a type of small area found chiefly on the western side of the pond. On the city land it is composed chiefly of chestnut and red oak. Some of the larger trees will make excellent ties or poles, so that the stand has a stumpage value considerably in excess of its cordwood value, or about $50 per acre. The thinnings amount to 10 cords, worth $1 per cord.

Pine and Hardwoods.

In this type hardwoods of medium size are mingled with pines of somewhat larger size. There are from 3 to 4 cords of pine box logs, as well as the regular run of 20 cords of hardwood to the acre. With a stumpage value of $5 a cord on the pine and $1 on the cordwood, the value of the stand by the acre is $40. In thinning, the pines should be favored, and the yield in cordwood will be the same as that of the medium hardwoods, — 2 cords. There will be no box logs among the thinnings.

Pasture and Bush Pasture.

Pasture land needs no description. Bush pasture is merely pasture land which is more than half covered with a growth of blueberry bushes, alders, hardhack and other impedimenta. This land should be planted before the cultivated land, for it is less valuable. Some difficulty may be experienced in setting out the trees, but usually room enough can be found among the clumps. Where the groups of bushes are extensive, lines should be cut through them 4 feet wide and 4 feet apart. This means an additional cost of planting of about $2 per acre average for all the land.

Bush Swamp.

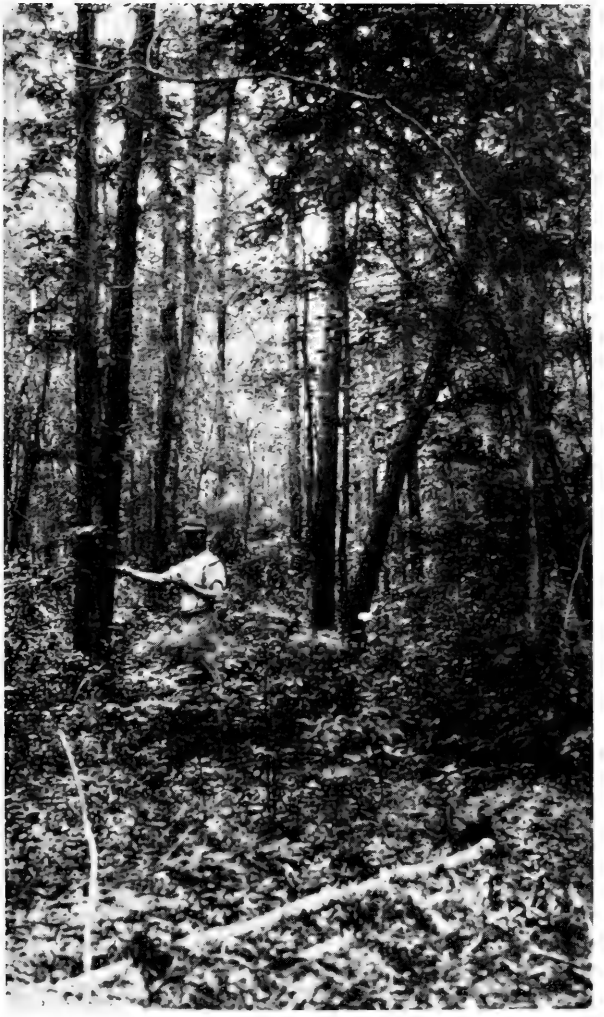
Detached portions of the shore line which are at times covered with water produce a thick crop of alder bushes. This type is of no importance, and no treatment of it need be considered.

Large Cedar Swamp.

This name is given to a portion of Blossom Swamp near the road, which has a growth peculiar to itself. The trees are chiefly coniferous. The leading species are pine, white cedar, hemlock and soft maple. Many of the trees are of box-log size, and the stand is therefore quite valuable. This stand is estimated to run 20 cords of box logs and 10 cords of hardwoods to the acre, which makes the stumpage value about $100 per acre. Although only a light thinning can be made in this swamp land, there are 1 cord of firewood and 2 cords of sound dead cedar which can be removed, — a value of $5 per acre.

Blossom Grove.

This is a group of large trees situated on the westerly side of Blossom Road, near the Cove. There are probably 100 M. board feet of lumber, mostly hemlock, since the pine has been cut, and worth on the stump $10 per 1,000, or $1,000 in all.



LARGE HARDWOODS.

(Colored Dark Orange on Map.)

Valuation.

We give below an estimate of the value of the timber growth which is of commercial value and is found on the city-owned land. This is the stumpage value, — that is, the value as it stands before being cut.

Blossom Grove type, 3 acres, 100 M. board feet timber,	$1,000
Large cedar swamp, 29 acres, 900 cords of wood, at $100 per acre,	2,900
Pine and hardwoods, 102 acres, at $40 per acre,	4,080
Large hardwoods, 81 acres, at $50 per acre,	4,050
Medium hardwoods, 230 acres, at $20 per acre,	4,600
Small hardwoods, 405 acres, at $14 per acre,	5,670
Maple, pine and hemlock, 42 acres, at $75 per acre,	3,150
Total stumpage of the woodland, not including that of the maple swamp, is	$25,450

Thinning.

The principle which underlies thinning is to be found in the struggle for existence and the survival of the fittest. For instance, on sprout land just cut off, a large number of young shoots spring up. For a time all grow vigorously, but as their crowns spread and meet a struggle ensues, during which the less active members are overtopped and cut off from the sunlight, and they die. There are exceptions. Hemlock and maple are what are called tolerant trees, and continue to live, although in deep shade. This conflict is not confined to any one period in the life of the forest, but is going on all the time. In this struggle much moisture and mineral elements in the soil are used up by trees which will never amount to anything, which elements had better be taken up by those who will.

For the purposes of thinning, four classes of trees are distinguished, — dominant, intermediate, suppressed and dead. Dominant trees are those which have their crowns in the light. The intermediate are crowded between the dominant, and are destined to be suppressed. Suppressed trees are those below the intermediate class, and have been cut off altogether from the sunlight; they will die in a few years. An average thinning would involve the taking out of all the suppressed and many of the intermediate class. In watershed protection we must be careful not to let in sun enough to dry the soil; so the intermediate class should be cut with care. Dead trees have lost their power of injuring other growth, but, as they furnish needless food to a forest fire, they should also be removed.

Other things than position determine what trees to come out. One of these is the species. Certain kinds are more valuable than others, and, other things being equal or nearly so, the most valuable species should be left. The order of preference in the neighborhood of Fall

River would be pine, chestnut, red oak, hemlock, white oak, cedar, maple and birch.

This order may again be modified in many cases by the condition of the tree; as, for example, a dominant pine tree of a valuable species might be suffering from a disease, in which case it should come out.

The task of selecting the trees to be thinned requires considerable experience and judgment, and should be in the hands of a trained man.

Thinnings are usually let out by the cord at a price somewhat in advance of that for cutting wood clean, because the process of selection makes it slower work. A greater part of the thinnings on the area in question, however, will not be fit for cordwood, and laborers working for the city have to be paid by the day, at the rate of $2.25. The usual basis for reckoning the expense of thinnings must therefore be changed. In the small hardwoods two men should be able to cut and pile the brush on about 1 acre a day. Among the medium hardwoods $\frac{1}{2}$ of an acre would make a full day's work, and among the large hardwoods $\frac{1}{4}$ of an acre would be the limit even for good choppers, because of the large amount of cordwood to be cut and piled. This makes the cost of thinning per acre respectively $4.50 to $6 for small hardwoods, $10 to $15 for medium, and $18 to $25 on the large. Where merchantable cordwood results from this work, its value should be deducted from the labor cost in order to obtain the net cost of the work. The value of cord wood piled in the woods is equal to its stumpage value, averaging $1, plus the average cost of chopping, which is $1.25 per cord.

Using the above figures, we obtain the following summary of the amount of thinning to be done and the net cost thereof: —

Small hardwoods: —
405 acres at $4.50 to $6.00 = $1,822 to $2,430. No returns.

Medium hardwoods: —
230 acres at $10 to $15 = $2,300 to $3,450; less 340 cords of wood at $2.25 a cord ($765), leaves a net cost of $1,535 to $2,685.

Large hardwoods: —
81 acres at $18 to $25 = $1,458 to $2,025; less 800 cords of firewood at $2.25 per cord, leaves a net profit of $342, or a net cost of $225.

Pine and hardwoods: —
102 acres at $10 to $15 = $1,020 to $1,530; less 200 cords of wood at $2 per cord ($400), leaves a net cost of $620 to $1,130.

Large cedar swamp: —
30 acres at $10 to $15 = $300 to $450; less 30 cords of wood at $1.50 per cord ($45) and 60 cords of dead cedar at $1 ($60), leaves a net cost of $200 to $350.

Maple, pine and hemlock: —
42 acres at $10 to $15 = $420 to $630; less 80 cords of wood at $1.75 per cord, leaves about $300 to $500 as the net cost.

Total cost of labor, $7,320 to $10,510; value of 1,500 cords of wood, $3,220; total net cost, $4,100 to $7,290 on 890 acres.

LARGE CEDAR SWAMP.

(Colored Blue on Map.)

Planting.

The land to be planted includes the cultivated, the pasture and the bush pasture types. There is an addition in the young sprout type 150 acres which were burnt over at the north end of the pond (lots 106–113), and some 60 acres, included in lots 149, 150, 153, 157 and 160, just cut off, where the reproduction is deficient, which might well be planted, although this last is not as important as the other areas. The tree to use in practically all cases is the white pine, for the following reasons: —

1. For causes given in the preliminary part of this report, conifers are the best protectors of a watershed.
2. It is one of the most rapid-growing trees in this section.
3. Of all forest tree seedlings, those of pine can be most readily obtained.
4. The species adapts itself easily to a wide range of soil and moisture condition.
5. White pine wood has a very general usefulness, and is therefore readily sold.

For planting purposes, two and three year old seedlings are used most commonly, but on exposed situations and among thick bushes one-year transplants are found to do better. These are three-year-old seedlings which in the second year were changed to another bed. The effect of the transplanting is to give the trees a stockier root system.

American nurserymen charge $4 per 1,000 for the seedlings, and $7 for the transplants. They can be obtained in Germany for $1.75 and $2.50, if bought in quantities of 100,000 or more. Freight, duty and other charges add about $2 to this cost. The European stock is fully as good as the native, and on account of superior methods of packing often arrives on this side in better condition than material from nurseries in the middle west. A good planting distance is 6 by 8 feet, which spacing requires the use of 900 plants to the acre. This makes the cost for seedlings average $3.50 per acre for foreign plants and $3.90 for native. On cut land which is to be interplanted the number of seedlings necessary to supply an acre would not be more than 500.

Four men and a boy make the most effective planting crew. Such a squad should set out 4 acres a day. This makes the labor cost $3 per acre. On the bush pasture there are $2 extra for cutting bushes. On the interplanted land the cost would be slightly less, say $2 an acre.

The exception to the white pine planting should be on lot 236. White pine is sensitive to strong winds, and on this exposed shore a slower-growing tree will do better. Norway pine is advised for use here, although the cost of the seedlings of the tree is as high as $8 per thousand.

The following summary gives the area to be planted, and the estimated cost: —

Cultivated land,	190 acres at $6.50 to $8.00=	$1,235 to	$1,520
Pasture land,	93 acres at 6.50 to 8.00=	605 to	744
Bush pasture,	67 acres at 8.50 to 10.00=	570 to	670
Burned land,	150 acres at 8.00 to 10.00=	1,200 to	1,500
Cut land interplanted,	60 acres at 4.00 to 5.00=	240 to	300
Cultivated land, lot 236, with Norway pine,	11 acres at 11.00 to 15.00=	120 to	165

Adding to this a sum to pay for tools, hauling and storage of seedlings and other incidental charges, brings the cost of the planting operations up to $4,000 to $5,000, more or less.

Fire.

Considerable care and attention must be given to this subject, because there is little profit in spending money on planting and improvement cuttings, if fire is to be allowed to undo the work. Only last spring one fire burned over an area of 200 acres at the north end of the pond, and another burned some 30 acres just south of the Yellow Hill Road.

The best protection against wood fires is watchfulness and prompt measures in fighting. At some high point on the west side of the pond a small observatory should be built, from which some one with a field glass could survey a large part of the watershed. During the dangerous seasons, which are usually from April 1 to May 15 and from October 1 to November 15, a man should go twice a day to this station and look for possible fires. Stored at some convenient place there should be four or five extinguishers, changes for reloading, and a number of shovels and hoes ready to be loaded on to a wagon when needed. Such an outfit would cost in the neighborhood of $100 to $150.

As an additional precaution, on both sides of the main roads for a distance of 25 feet the underbrush should be cut away and the ground burned over. This work would be done, of course, only on city land, and at places where the roads ran through the woods. As far as possible, the wood roads should be treated in the same manner. The cost of this work is about $20 to $50 per mile, and it would need to be repeated every third year, although the succeeding expense would

LARGE CHESTNUT GROWTH.

(Colored Dark Orange on Map.)

not be as great. It is estimated that about 12 miles of these fire lines will be sufficient. These lines will not stop a fire unaided, but they are convenient places at which to make a stand in cases where the fire has too much of a start to permit of its being extinguished in the woods.

Superintendence.

To carry out the provisions of the above report will require several years' time and some thousands of dollars in money. The work should have, at the commencement at least, the supervision of a trained man. Foresters do not come high. An active young man with a college training can be secured at a salary of approximately $1,000 a year. He should have as a permanent assistant some man fond of outdoor work and life in the woods. Temporary help needed in the work of planting and cutting can be hired from time to time. The pay of the assistant would all be included in the general expense of the several lines of work. The professional forester would not be wholly an extra expense, and about one-half of his salary, representing the value of his manual work, should be credited to the expense of the work already estimated; the other half represents the value of his professional knowledge, and is an additional charge. If this work were spread over a period of five years, this additional charge would be $2,500. It would be quite essential that the forester have the use of a stout horse and wagon, for hauling plant material, carting away brush from fire lines, carrying the fire apparatus, etc. This represents a charge of about $200 a year, which includes the cost of keeping and something for depreciation on the outfit.

If it is not considered feasible to hire a permanent forester to supervise the work, it might be possible to engage the services of a consulting forester, who would give a specified amount of time to the supervision of the forestry work on the watershed. Such contracts, we believe, often exist between park departments and landscape architects. Of course the cost of such supervision would depend entirely on the agreement made by the Reservoir Commission and the consulting forester; but the figure $500 used in the tables below ought amply to cover this item of expense.

Financial Summary.

Net cost of thinning work,	$4,100 to	$7,300
Cost of planting work,	4,000 to	5,000
Fire protection: —		
Apparatus, $100; fire lines, $450 to $600; watch tower, $50,	600 to	800
Net cost of services of a forester, five years,	2,500	
Use of horse and wagon, five years,	1,000	
	$12,000 to	$16,600

The cost by years should be apportioned about as follows: —

First Year.	
First thinning (one-fifth total), 180 acres,	$820 to $1,460
Planting (one-fifth total), 76 acres,	800 to 1,000
Fire apparatus,	100 to 150
Fire lines (one-half),	225 to 300
Watch tower,	50
Forester,	500
Horse and wagon,	200
Tools and supplies,	50
Total,	$2,745 to $3,710
Second Year.	
Thinning (one-fifth),	$820 to $1,460
Planting (one-fifth),	800 to 1,000
Fire lines (one-half),	225 to 300
Forester,	500
Horse and wagon,	200
Tools and supplies,	20
Total,	$2,565 to $3,480
Third Year.	
Thinning,	$820 to $1,460
Planting,	800 to 1,000
Forester,	500
Horse and wagon,	200
Tools and supplies,	50
Total,	$2,190 to $3,210
Fourth Year.[1]	
Thinning,	$820 to $1,460
Planting,	800 to 1,000
Fire lines,	100 to 200
Forester,	500
Horse,	200
Supplies,	25
Total,	$2,475 to $3,385

Sample Acre. — Small Hardwoods.

Diameter Breast High (Inches).	Class I.			Class II.[2]				
	White Oak.	Red Oak.	Chestnut.	White Oak.	Red Oak.	Maple.	Chestnut.	Dead.
1,	–	–	–	10	–	40	32	32
2,	–	–	–	90	84	43	57	122
3,	–	80	13	–	55	–	15	17
4,	16	72	77	–	3	–	–	–
5,	–	40	91	–	–	–	–	–
6,	–	21	39	–	–	–	–	–
7,	–	–	6	–	–	–	–	–
Total,	16	213	226	100	142	83	72	–

Average height, Class I., 32 feet; Class II., 20 feet. Trees to the acre, 850; merchantable cordwood, 14 cords; no merchantable yield in thinnings.

[1] Fifth year the same.

[2] Class II. represents the trees that would come out in the work of thinning.

Sample Acre. — Small to Medium Hardwoods.

Diameter Breast High (Inches).	Class I.					Class II.			
	Red Oak.	White Oak.	Chestnut.	Pine.	Maple.	Black Oak.	White Oak.	Maple.	Dead.
1, ...	–	–	–	–	–	–	8	–	–
2, ...	–	–	–	–	–	16	80	88	96
3, ...	–	80	–	24	8	–	24	–	48
4, ...	8	24	8	–	–	–	–	–	16
5, ...	32	40	32	–	–	–	–	–	–
6, ...	–	–	24	8	–	–	–	–	–
7, ...	–	8	40	8	–	–	–	–	–
8, ...	16	–	–	–	–	–	–	–	–
10, . . .	–	–	–	–	–	–	–	–	–
Total, . .	56	152	104	40	8	16	112	88	–

Average height, Class I., 40 feet; Class II., 25 feet. Trees to the acre, 580; merchantable cordwood, 16 cords; no merchantable yield in thinnings.

Sample Acre. — Medium Hardwoods and Pine.

Diameter Breast High (Inches).	Class I.						Class II.					
	White Oak.	Red Oak.	Chestnut.	Maple.	Beech.	Pine.	White Oak.	Black Oak.	Maple.	Beech.	Pine.	Dead.
1, ...	–	–	–	–	–	–	16	–	32	–	–	32
2, ...	–	–	–	–	–	–	40	18	60	8	14	16
3, ...	32	–	8	14	8	32	8	–	–	8	–	19
4, ...	16	32	–	20	6	48	–	–	–	–	–	–
5, ...	16	16	8	–	6	–	–	–	–	–	–	5
6, ...	–	56	24	–	–	16	–	–	–	–	–	–
7, ...	–	24	32	–	–	8	–	–	–	–	–	–
8, ...	–	8	24	–	–	14	–	–	–	–	–	–
9, ...	–	8	8	–	–	–	–	–	–	–	–	–
10, ...	–	–	–	–	–	5	–	–	–	–	–	–
Total, . .	64	144	104	34	20	123	64	18	92	16	14	–

Average height, Class I., 45 feet; Class II., 30 feet. Trees to the acre, 690; merchantable cordwood, 22 cords; pine box logs, 2½ cords; thinnings, 2 cords.

SAMPLE ACRE. — LARGE HARDWOODS, CHESTNUT AND RED OAK.

DIAMETER BREAST HIGH (INCHES).	CLASS I.		CLASS II.		
	Chestnut.	Red Oak.	Chestnut.	Red Oak.	Dead.
2,	–	–	–	16	–
3,	–	–	–	32	7
4,	8	–	12	32	30
5,	–	–	8	36	5
6,	8	–	32	14	–
7,	16	24	16	–	–
8,	32	40	–	–	–
9,	48	16	–	–	–
10,	32	–	–	–	–
11,	29	–	–	–	–
Total,	163	80	68	130	42

Average height, chestnut, Class I., 58 feet; Class II., 45 feet; oaks, Class I., 52 feet; Class II., 38 feet. Trees to the acre, 440; firewood, 32 cords; ties, 92; thinnings, 11 cords.

SAMPLE ACRE. — LARGE CEDAR SWAMP, CONIFEROUS SWAMP GROWTH.

DIAMETER BREAST HIGH (INCHES).	CLASS I.				CLASS II.			
	Cedar.	White Pine.	Maple.	Hemlock.	Cedar.	Maple.	Hemlock.	Dead.[1]
3,	12	–	–	–	–	–	4	4
4,	8	–	–	–	8	4	4	12
5,	12	–	8	8	–	–	4	16
6,	8	4	12	8	–	–	–	12
7,	28	4	20	16	–	–	–	4
8,	52	12	16	12	–	–	–	4
9,	36	–	8	–	–	–	–	–
10,	24	4	8	12	–	–	–	–
11,	12	4	16	4	–	–	–	–
12,	8	8	–	–	–	–	–	–
13,	–	8	–	–	–	–	–	–
Total,	150	44	88	60	8	4	12	52

Average height, Class I., cedar, 45 feet; pine, 60 feet; maple, 60 feet; hemlock, 50 feet; Class II., all 40 feet. Trees to the acre, 366; merchantable conifers, 27 cords; merchantable thinnings, 1 cord; dead cedar, 2 cords; maple, 10 cords.

[1] Largely cedars in sound condition.

Sample Acre. — Large Hardwoods in Low, Moist Land.

Diameter Breast High (Inches).	Class I.						Class II.				
	Red Oak.	White Oak.	Maple.	Yellow Birch.	Ash.	Poplar.	White Oak.	Maple.	Black Oak.	Poplar.	Dead.
1,	–	–	–	–	–	–	4	16	4	–	36
2,	–	–	–	–	–	–	32	40	28	12	30
3,	–	–	–	–	–	–	20	–	4	8	12
4,	–	–	–	–	–	–	12	–	8	–	8
5,	–	24	36	–	8	–	4	4	–	–	–
6,	4	4	8	8	8	–	–	–	–	–	–
7,	8	16	16	4	–	–	–	–	–	–	–
8,	8	12	4	–	–	–	–	–	–	–	–
9,	4	–	4	–	–	–	–	–	–	–	–
10,	24	–	16	8	–	8	–	–	–	–	–
11,	8	–	8	–	–	–	–	–	–	–	–
12,	12	8	20	–	–	–	–	–	–	–	–
13,	4	4	4	–	–	–	–	–	–	–	–
14,	–	–	–	–	–	–	–	–	–	–	–
16,	4	–	–	–	–	–	–	–	–	–	–
17,	4	–	–	–	–	–	–	–	–	–	–
Total,	80	68	116	20	16	8	72	60	44	20	86

Average height, Class I., 60 feet; Class II., 30 feet. Trees to the acre, 502; after thinning, 308; merchantable cordwood, 42 cords; merchantable thinnings, 1½ cords; brush wood, 2 cords.


CRVI

Forest Map

Watershed

OF

NORTH WATUPPA POND

Fall River, Mass.

Scale of Feet

1000 2000 3000 4000 5000

1908

MASS. STATE FOREST SERVICE

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